AirZOne

Mechanistic Modelling Approaches to Pollen-mediated Gene Flow and Confinement

Franco DiGiovanni

Presentation Outline

- Introduction
- Models - Overview
- Factors Affecting Pollen Dispersal by Wind
- Models for Wind Vector
- Regulatory Application for Risk Assessment

Introduction: Why a problem?

- Seed production
- Environmental and human health concerns
- Authorizations for releases ← Environmental risk assessments
- One aspect of the assessment is pollen/gene-flow
- Modelling an important tool

Introduction: Pollination

- Pollination mode: Out-crossing ↔ selfing
- Vector: insects ↔ wind
- Common wind pollinated crops: corn, canola, Millet, oats, wheat

Introduction: Containment

- Biological: induced male sterility, etc., temporal isolation
- Physical methods: distance isolation, barrier crops, windbreak-like structures
- Suggested based on measurement but pollen/gene flow highly variable

Models - Overview

- Modelling vs measurement
  - Site-specific measures not generalizable
  - Difficult to assess variability in pollen/gene flow measures
  - Models can predict
- Empirical vs mechanistic vs genetic

Models – Mechanistic

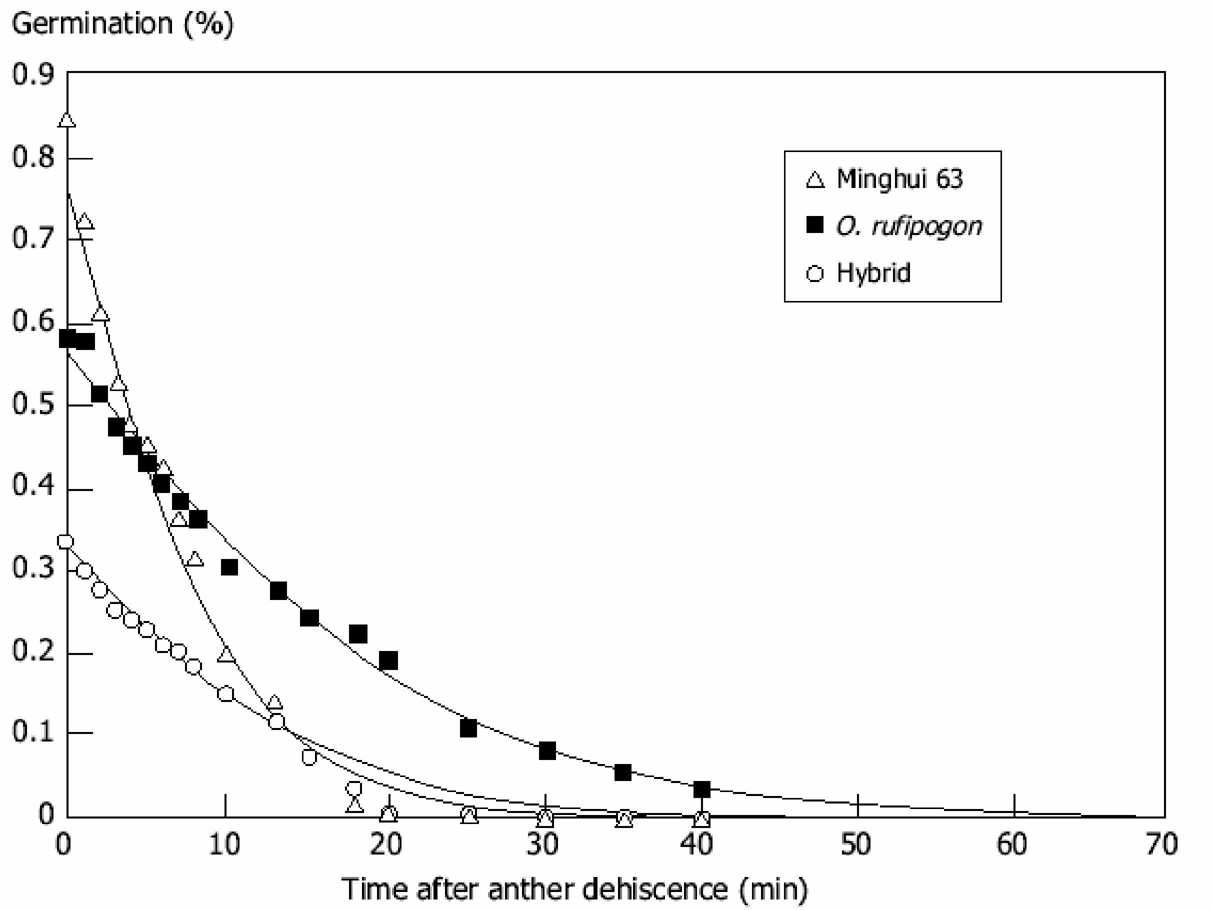
- Based upon physics/chemistry of processes
- Wind vector: physics of atmospheric dispersal
- Insect vector: quasi-mechanistic

Models – Overview

- Pollen/gene flow cannot be entirely modelled mechanistically
- Must deal with sub-processes separately and split into “mechanistic” and “biological” sub-process
- Easy to do because most (modern) models are modular

AirZOne

Models – Biological sub-processes



In vitro pollen germination after anther dehiscence. The nonlinear regression was $Y_{\text{Minghui 63}} = 1.92/(1 + 1.376 \exp^{(0.177x)})$, $R^2 = 0.99$; $Y_{O.rufipogon} = 0.88/(1 + 0.616 \exp^{(0.093x)})$, $R^2 = 0.98$; $Y_{hybrid} = 0.413/(1 + 0.309 \exp^{(0.179x)})$, $R^2 = 0.99$, respectively.

(Song *et al.* 2001)

Models – Overview

- The more heavily the model relies on empirical sub-processes the less likely it is to easily generalizable.

Factors affecting Outcrossing in Wind Pollinated Plants

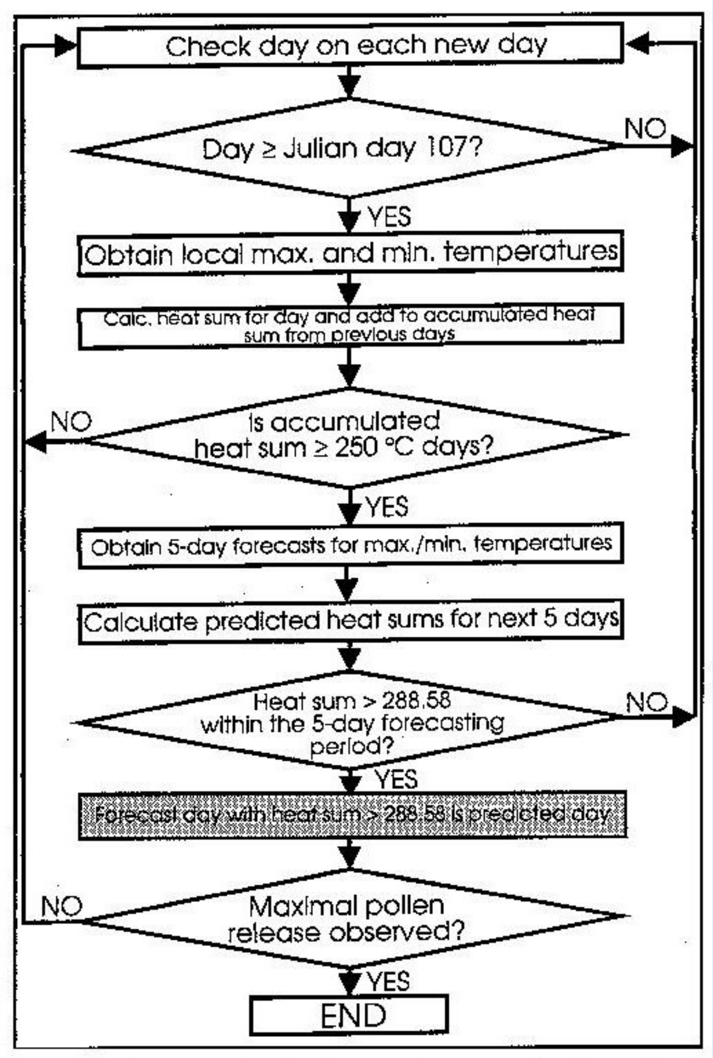
- Source
- Dispersal
- Deposition → fertilization

AirZOne

Source

- # pollen released/plant
- Height of release
- temporal cycles and variability - environmental factors

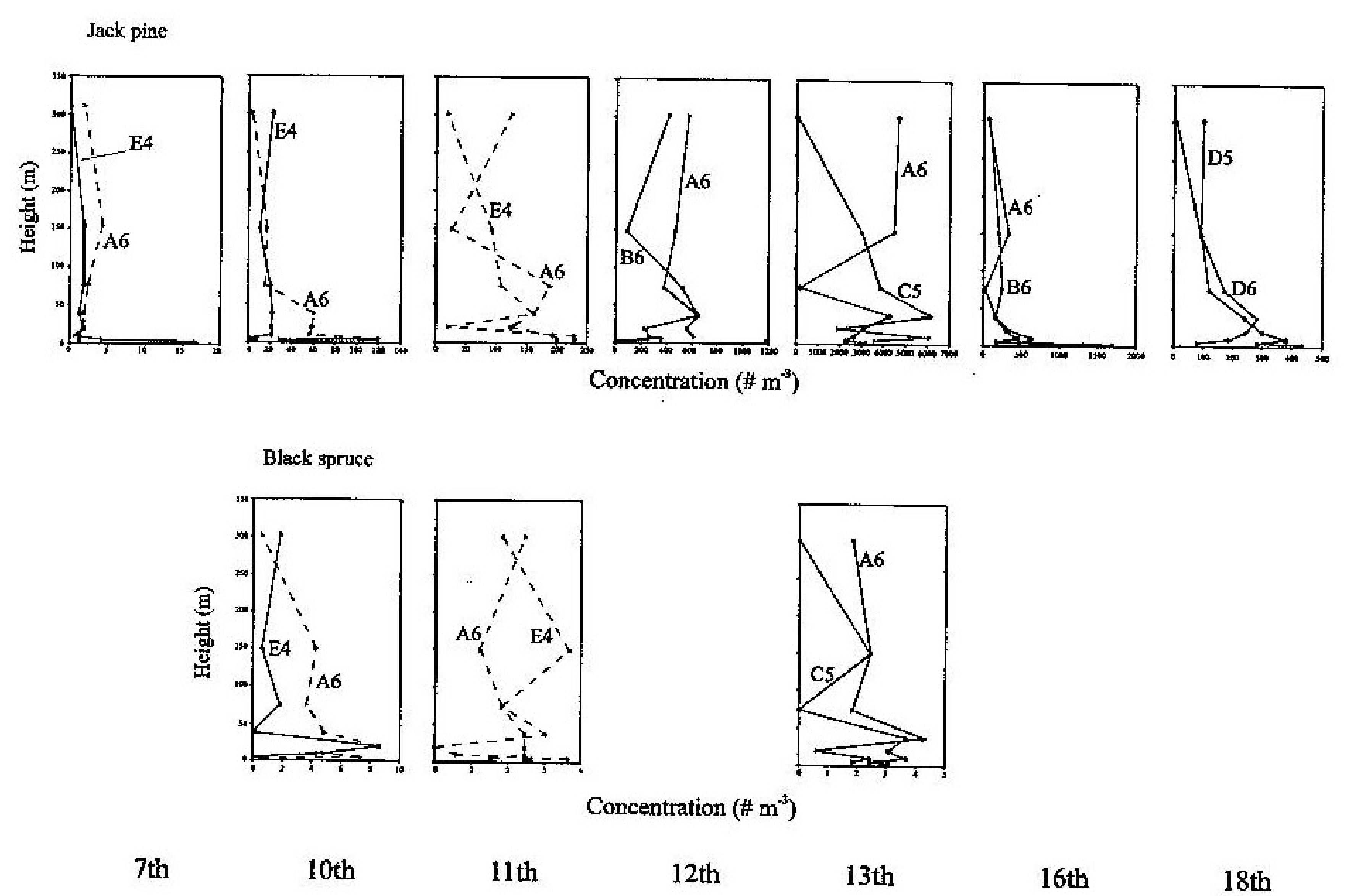
Timing of Pollen Release



Dispersal

- Wind speed
- Atmospheric stability
- Pollen settling velocity - weight, rh(%)

Dispersal

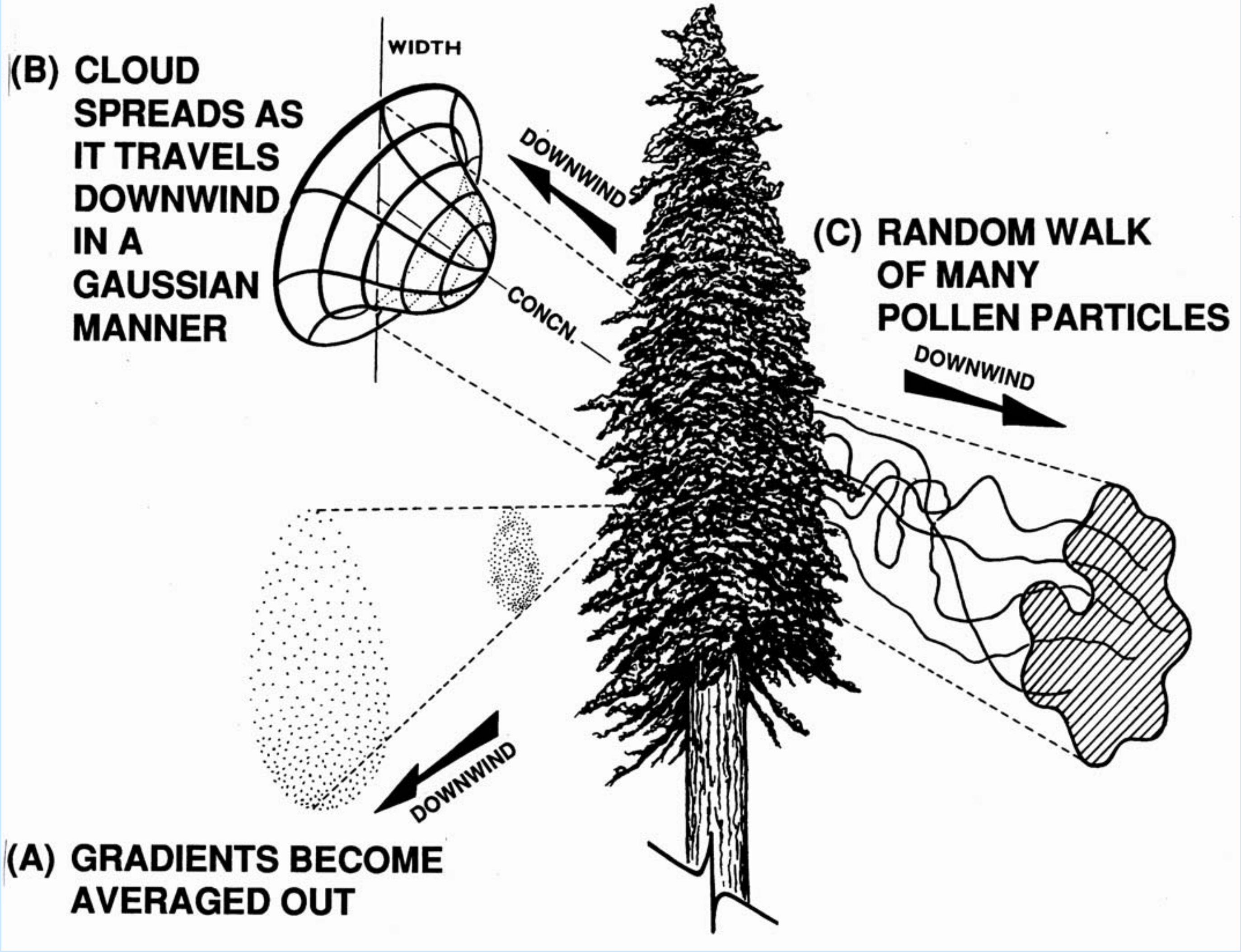

Jack pine
Height (m)
E4
A6
B6
C5
D5
D6
Concentration (# m⁻³)
Black spruce
Height (m)
E4
A6
C5
Concentration (# m⁻³)
7th
10th
11th
12th
13th
16th
18th

Deposition

- Ground
- Vegetative parts: f(settling velocity, wind speed, size of plant element)
- stigmas → gene-flow
- Gene-flow: viability - environmental conditions

AirZOne

Models for the Wind Vector



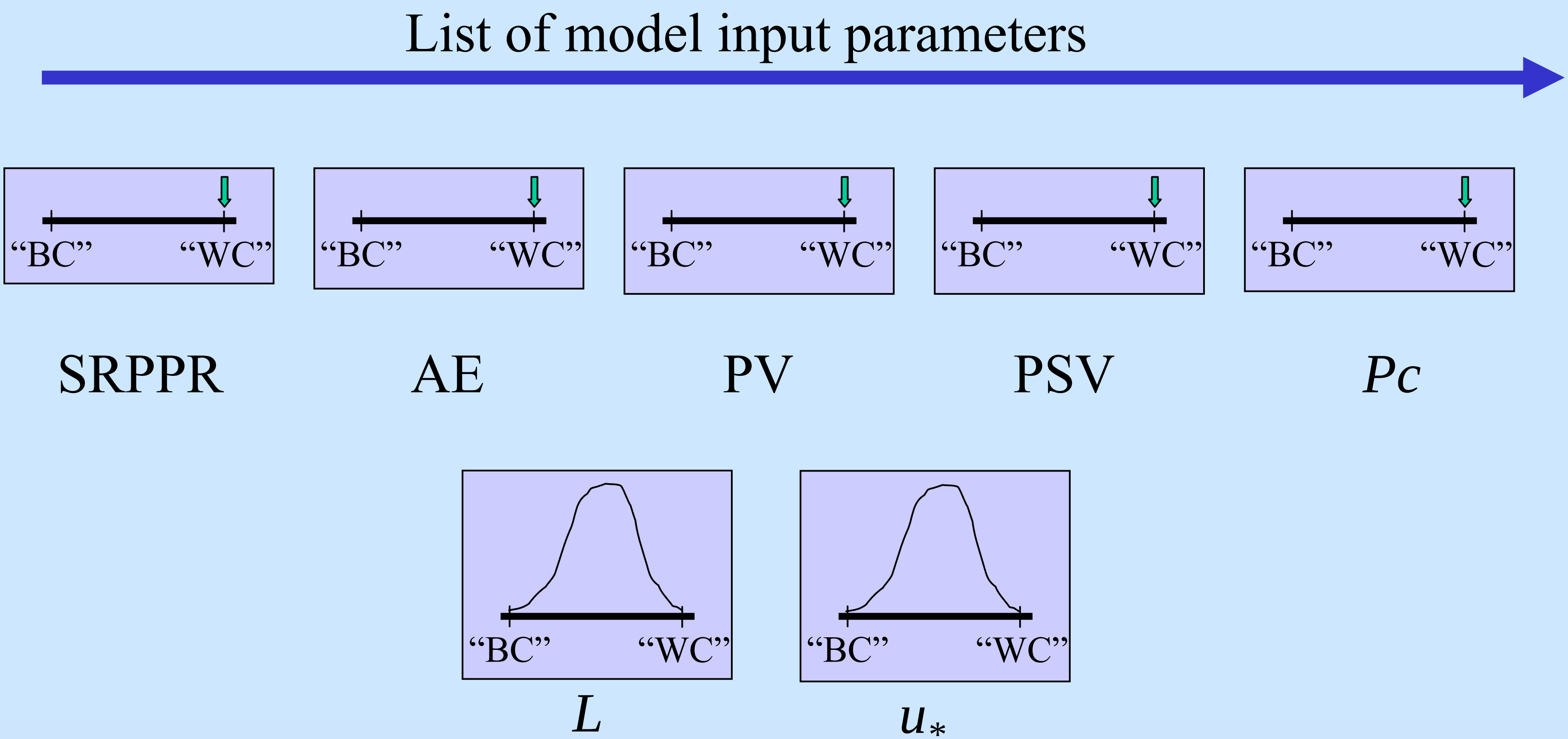
Regulatory Application of Models for Risk Assessment

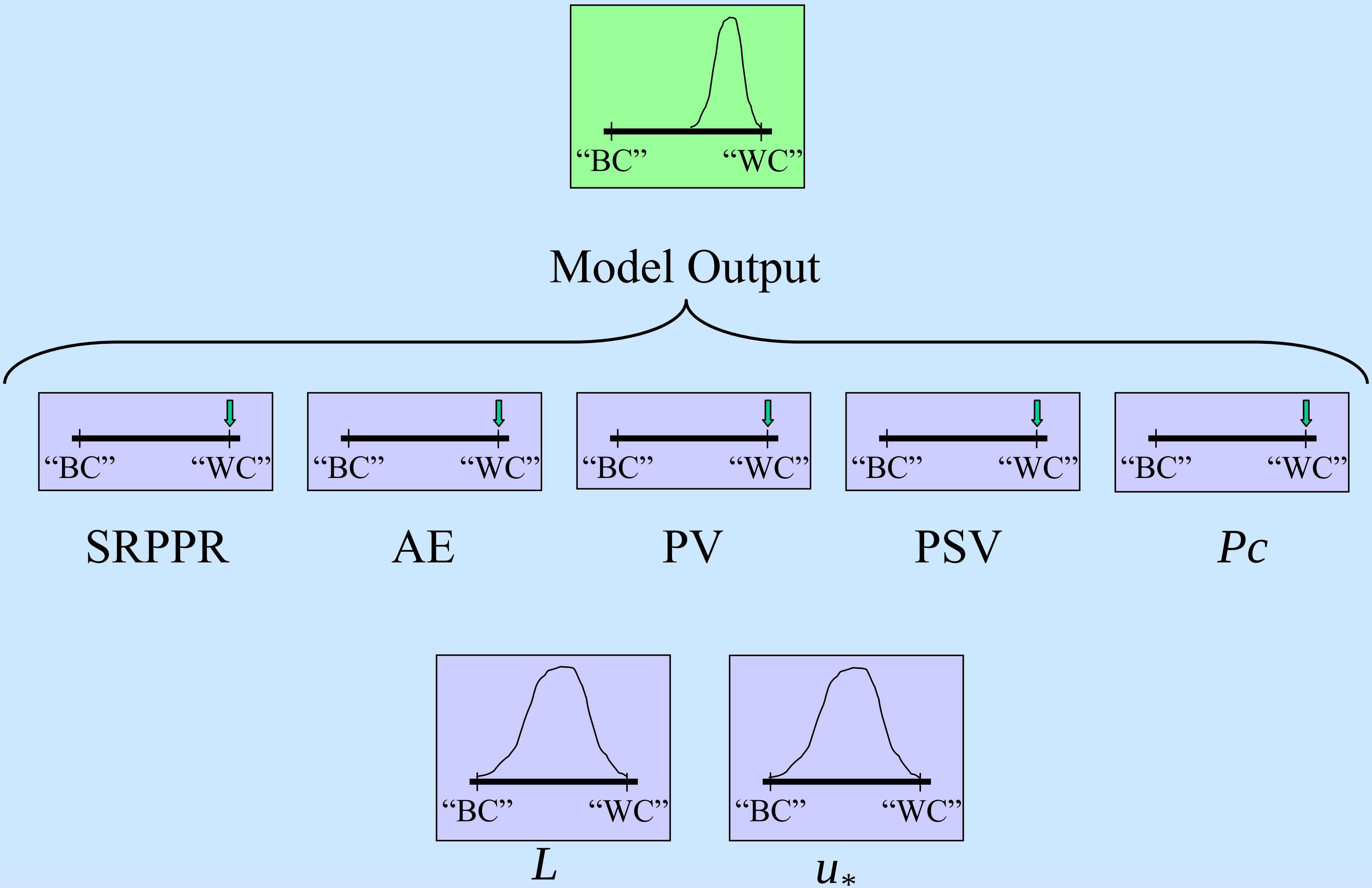
- Develop/validate appropriate dispersal models
- conversion to gene-flow
- run for various sites with long-term meteorological data → determine variability
- run with alternative isolation techniques

Specification for Wheat

- Some input parameters ill-defined
- Set to “maximum” → conservative model outputs
- Potential regulatory application

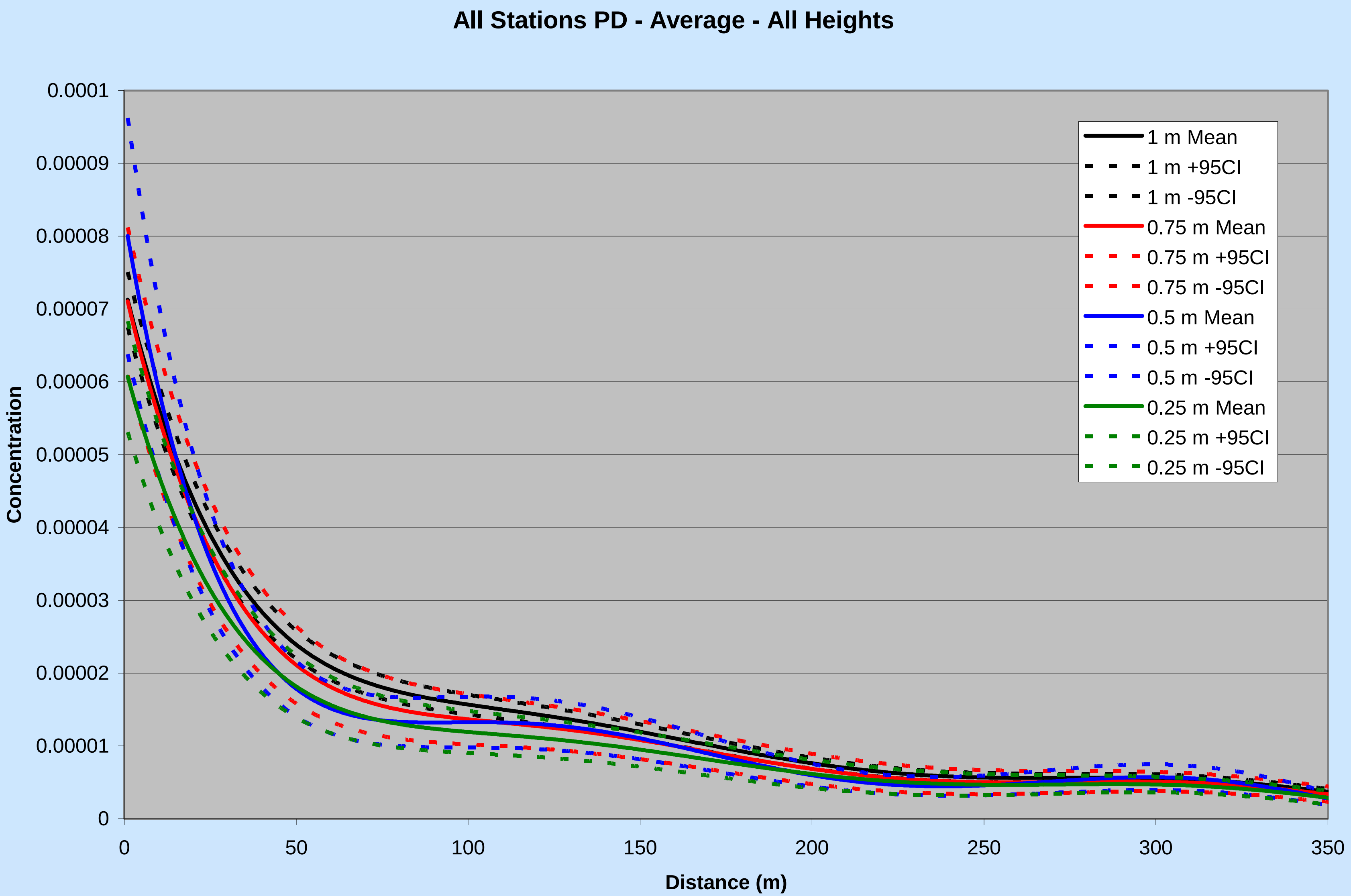
Dealing with a Lack of Input Data




"BC"
"WC"
Model Output
"BC"
"WC"
SRPPR
AE
PV
PSV
Pc
L
u*

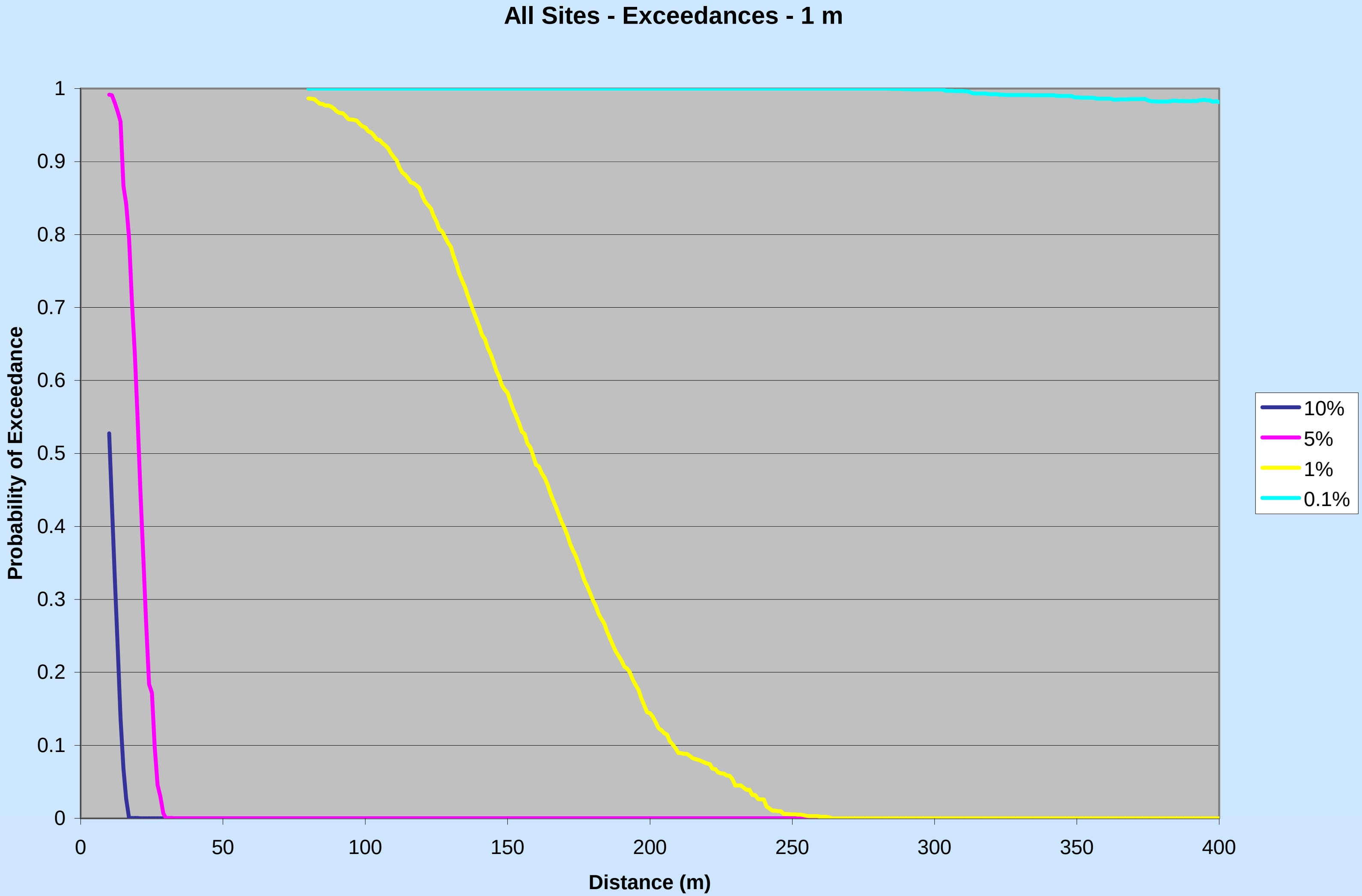
AirZOne

Pollen Dispersion



AirZOne

Probability of Exceeding an OC Threshold

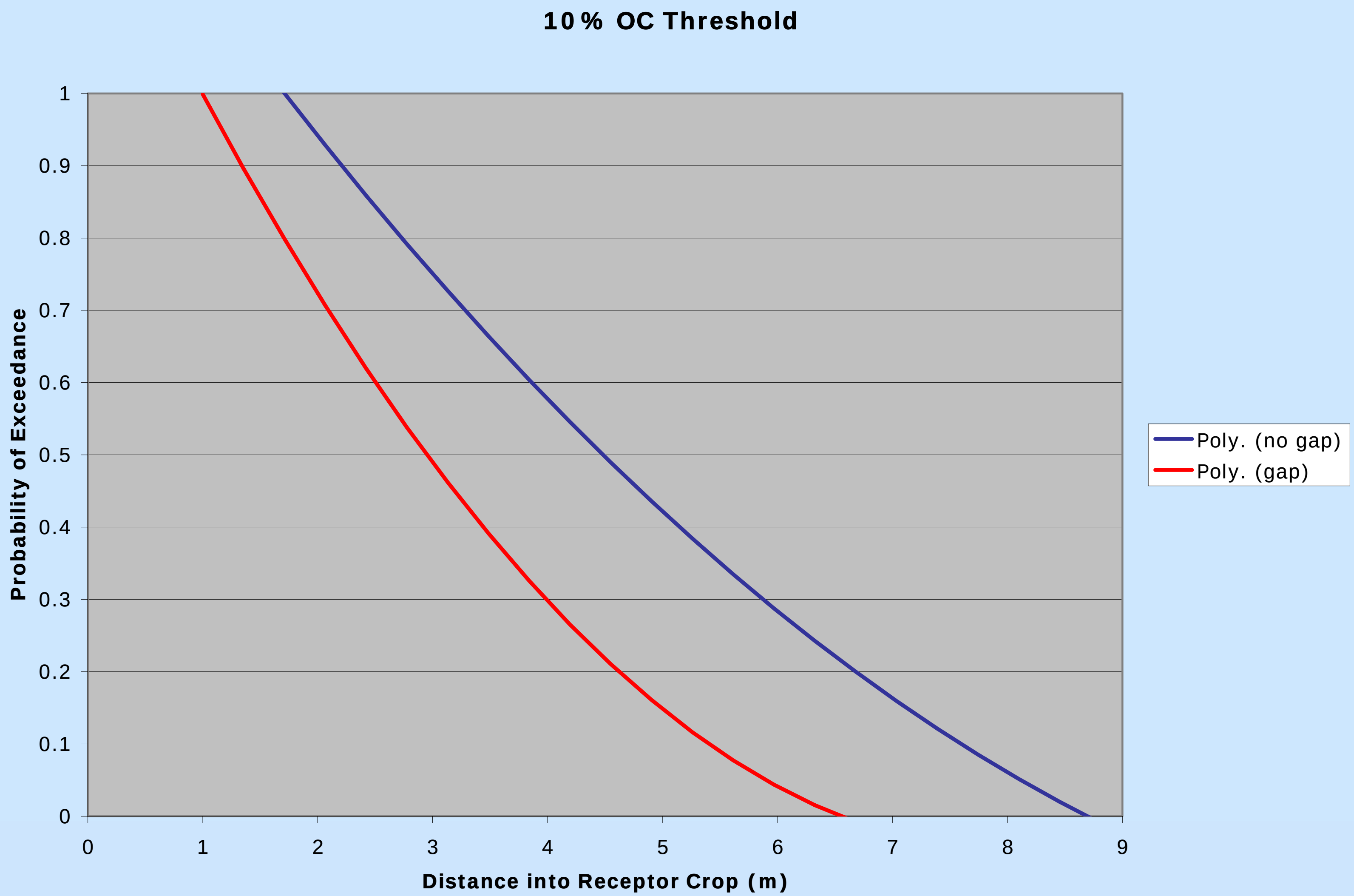


Different Isolation Methods

1. Barrier crops
2. Barren isolation zones
3. Windbreak-like structures
4. Flowering desynchronization

AirZOne

Different Isolation Methods: Barren isolation zones



Summary

- Modelling will be a very useful tool in the regulatory risk assessment of novel plants
- They can be used to assess present and novel containment methods
- Maximizing the mechanistic content of models should be the ultimate goal
- However, substantial use can be made of models at present
- Appropriate model required for the appropriate situation
- OC and containment should be assessed on a probabilistic basis given their variability